MGG09005051

IR NO. 70-13

INFORMAL REPORT

ACOUSTIC SEA BED REFLECTIVITY FROM A SUBMERSIBLE

MARCH 1970

NAVAL OCEANOGRAPHIC OFFICE
WASHINGTON, D.C. 20390

INFORMAL REPORT

The Informal Report (IR) as produced at the Naval Oceanographic Office is a means for personnel to issue timely scientific and technical preliminary reports of their investigations. These are primarily informal documents used to report preliminary findings or useful byproducts of investigations and work to members of the scientific and industrial communities.

Informal Reports are assigned sequential numbers for each calendar year; the digits preceding the dash indicate the year.

The distribution made of this report is determined primarily by the author. Information concerning obtaining additional copies or being placed on a distribution list for all future Informal Reports in a given area of interest or specialty field, should be obtained from:

Field Management and
Dissemination Department
Code 4420
Naval Oceanographic Office
Washington, D.C. 20390

Contents

Figures

ABSTRACT

Acoustic bottom reflectivity measurements made from the submersible ALUMINAUT at two sites in the Caribbean show unusually low bottom losses compared to similar measurements made in the past from surface ships. The reason for these low losses is explored but no satisfactory theory can be postulated. The submersible technique is inherently superior to that usually deployed from a surface ship and removes many of the variables associated with a surface experiment. Further experimentation is required to develop the technique and confirm the low losses.

by KENNETH R. HAIGH

Deep Vehicles Branch
Developmental Surveys Division
Oceanographic Surveys Department

This manuscript has been reviewed and is approved for release as an UNCLASSIFIED Informal Report.

B.C. Byrnes

B.C.BYRNES
Director
Developmental Surveys Division

ACOUSTIC SEA BED REFLECTIVITY FROM A SUBMERSIBLE

INTRODUCTION

Measurements of the acoustic reflectivity of ocean floor sediments, have in the past usually been carried out from surface ships. Narrow band measurements using the ship's echo sounder have been the most popular, but some wideband work using explosive sound sources has been executed.

Surface ship investigations both narrow and wideband, contain a number of features which can color the results and which cannot easily be isolated. In the use of an echo sounder the following variables can affect the reflectivity measurements:

1. Quenching; due to ship movement causing aeration around the hull and across the face of the transducer, the projector source level and the receiver sensitivity can be adversely affected.
2. System geometry; movement of the ship, even in still water results in variable measurements.
3. Insonified area; the area of sea bed illuminated varies with the depth of water. With the normal navigational echo sounder the area illuminated in a depth of 2 kilometers is a circle 1 kilometer in diameter. Gross changes in topography and sediments can be encountered within the illuminated area with no precise knowledge being available, on the surface, of the controlling factor in the acoustic return.

4. Delineation; the definition of a navigational echo sounder even with a modern frequency-controlled display is inadequate to delineate the microtopography of the bottom. No modern precision depth recorder can be read to an accuracy of better than 4 meters in a depth of water of 4000 meters. A 10 kHz echo sounder with a wavelength of 15 cmc cannot delineate better than 30 cms and thus cannot be used to judge roughness with the degree of accuracy required. Normal procedure is to gauge the roughness from ancillary bottom photography.

When using a broadband explosive signal, quenching is eliminated, system geometry problems are minimized if the depth of the explosive is chosen with care to eliminate subsidiary reflections, the insonified area is reduced in area but the problem of delineation is as difficult as the echo sounder case.

Both the narrow band and wide band measurements require sophisticated electronic systems to handle the very large range of signals between the source and echo; at 3650 meters and 10 kHz the water column loss alone is 84 db (1) for the two way path.

In spite of the foregoing limitations, two very large surveys have been completed using the principles described. The NAVADO project (2) of the Admiralty Underwater Weapons Establishment, had objectives of assessing the distribution of bottom reflectivity on a geographic basis together with understanding the nature of the reflection mechanism and the reasons for variable reflectivity.

The Marine Geophysical Survey (3) (MGS) of the U.S. Naval Oceanographic Office, had the specific objective of assessing the likely performance of bottom-bounce sonar on a geographical basis.

In the scientific study of the reflection process, as distinct from an operational survey, a great improvement in technique can be achieved by the use of a deep-diving submersible as a stable measurement platform free from surface effects and in a position to observe and measure directly the controllable area of sound illumination.

The opportunity arose to carry out some reflectivity measurements during a geophysical trial in the submersible ALUMINAUT chartered by the Deep Vehicles Branch of NAVOCEANO. No provision for the measurements was made in the original trial program and consequently, reflectivity was explored on an ad-hoc basis using available facilities.

REFLECTIVITY SITES

An area off the south coast of Vieques Island, Puerto Rico had been selected as the location of the main geophysical trial. Within this area two sites were chosen for the bottom reflectivity measurements on the basis of the most likely spots to possess different sediment properties. Areas possessing gross topographic features were avoided, the two sites being flat other than for fine-scale roughness.

A fine-scale bathymetric survey of the area had previously been carried out from the surface, but on diving to the bottom in ALUMINAUT the well known errors associated with wide beam echo sounders were only too apparent. The regularly spaced bathymetric contours of the chart indicating an island rise, were absent, giving way to a large comparatively flat area followed by almost sheer cliffs as observed from the submersible.

The first site chosen for reflectivity work was in a depth of 1706 meters over a flat area, the second site was in 1189 meters of water where the sediment thickness appeared to be thinner but the amount of microtopography (features $<$15 cms vertical relief) was greater.

EQUIPMENT

A simple wideband explosive trial was conceived using equipment already installed in ALUMINAUT, the only additional requirement being that of the explosive source, which was fulfilled by obtaining Dupont Electric Blasting Caps Special No. 8 from the naval facility at Roosevelt Roads, Puerto Rico. These devices contain 1gm of explosive.

The experiment consisted of exploding the blasting caps at a depth of 2 meters, whilst ALUMINAUT, hovering 30 meters above the bottom recorded the level of the sound on its way down to the bottom and also after reflection on its way back to the surface;

the bottom loss at normal incidence is simply the difference between the two. By these means the affects of the water column were eliminated, variability of the source level was of no consequence, system geometry was stable, the area illuminated was small and the electronic equipment required no more dynamic range than that of the bottom loss.

A wideband transducer and pre-amplifier with a 42 db gain were mounted on a boom clear of, but attached to ALUMINAUT, whilst inside the boat the pre-amplifier output was fed direct to a seven channel Lockheed recorder, one channel recording the analogue explosive information whilst other channels contained a CW calibration signal and voice editing.

The hydrophone used was Atlantic Research Model LC 58 which is omni-directional and capable of operation down to 6100 meters.

Analysis consisted of playing the analogue tapes through 1/3 octave band filters and recording the signals on a high speed ultra violet chart recorder. The peak of the direct and indirect signals were obtained from the ultra violet paper. Approximately one hundred shots were recorded at the two sites.

PROCEDURE

Investigations at normal incidence grazing angles only were carried out due to the difficulties of underwater positioning of the submersible. It is a simple matter to place the mother ship directly over the submersible, but until such time as underwater navigation is sophisticated enough to allow the mothership to leave her child, shallow grazing angles will not be possible unless the sound source is also close to the bottom e.g. a second submersible to carry out forward scattering investigations.

No precise time measurement was available in ALUMINAUT nor is it feasible to pass time of fire information over an acoustic link, consequently no travel time measurements were possible. The shots were exploded at intervals of roughly one minute, recording continuously in the submersible. At the end of each series of explosions the reflectivity sites were surveyed visually and photographically to observe the scale of the topography.

EXPLOSIVE CHARACTERISTICS

No acoustic data of any kind was available on the Dupont Blasting Cap Special Number 8, at the time of the trial. To avoid interference from surface reflections the caps were exploded just below the surface; it subsequently proved to be a depth where bubble pulse migration was possible but this did not produce any difficulties in the analysis. Sample explosions were recorded with ALUMINAUT at mid-depth to record the explosion characteristic. The migratory bubble pulse occurred 30 milliseconds after the shock wave. Fig. 1 indicates the filtered shot characteristics, while Fig. 2 shows the characteristics of the individual components of the wideband signal.

RESULTS

Analysis of the acoustic results is shown in Table I and the histograms of Figs. 3 and 4.

TABLE I

SITE 1

Band	Number of Measurements	Mean Bottom Loss	Standard Deviation
250 Hz	48	3.09 db	2.37
500 Hz	52	0.80 db	2.80
1000 Hz	53	2.93 db	2.69
2 kHz	53	3.68 db	2.28
4 kHz	52	1.93 db	2.26
8 kHz	53	3.25 db	2.28
Broadband	53	2.22 db	1.21

SITE 2

Band	Number of Measurements	Mean Bottom Loss	Standard Deviation
250 Hz	32	2.19 db	2.21
500 Hz	31	0.79 db	3.23
1000 Hz	32	2.66 db	2.83
2 kHz	32	0.84 db	2.58
4 kHz	32	+0.33 db	2.18
8 kHz	28	1.14 db	2.12
Broadband	31	0.68 db	1.40

Bottom photographs of Site 1 at position Lat. 18°00.95'N, Long. 65°38.45'W and of Site 2 at position Lat. 18°01.33'N, Long. 65°38.15'W, are shown in Figures 5 and 6 respectively. Visual observation of both sites indicates a calcareous ooze, Site 1 being overlaid with an organic fuzz. Site 1 microtopography was smooth within undulations of 2 1/2 cms with an occasional animal working not exceeding 15 cms in height or depression. Site 2 showed more animal working with a generally greater amount of microtopographical relief although the amplitudes were not greater than Site 1.

Core analysis of a sample taken in the vicinity of Site 1 is shown in Fig. 7 where confirmation of the calcareous content is obtained. The upper six centimeters of the core may be described as clayey-silt followed by silty-sand from six to ten centimeter depth.

DISCUSSION

The most striking feature of the results obtained is the low value of measured bottom reflectivity and its virtual independence of frequency. In seeking an explanation for this, consideration was given to the following. Water column anomalies were ruled out due to the virtual absence of any water path in the experiment. Source level considerations were excluded due to the measurement of direct and reflected energies. Equipment limitations may be excluded by reason of the low dynamic range required, the absence of any indication of overloading on the records and the normal distribution of the histograms of bottom loss. Interference from sub-bottom layers may also be ruled out as the shot-to-shot echoes showed no evidence of sub-bottom layers; supporting this, the corer penetrated to a depth of 79 cms. Additionally, the possible effect of reflections from ALUMINAUT was investigated, the system geometry was analyzed for phase cancellations or summations, but no satisfactory explanation for this low value of bottom reflectivity and individual positive measurements could be found. Possible focussing of the sound was also investigated but no evidence of this happening was found. The terrain was virtually flat and examination of stereoscopic pairs of photographs revealed nothing but random distribution of the sides of small undulations which conceivably could form facets of a reflector.

From consideration of the ratio of the specific acoustic impedances of the water and the sediment, the bottom loss should be of the order of 14 db. This value was calculated from bottom observed water temperature of 3.89°C and a salinity of 34.97°/00; sediment properties were assumed for a clayey-silt of density 1.50 gm/cc and a velocity of 1535 m/sec. Even a bottom of near 100% porosity, such as that of fine clay will produce a bottom loss of 6 db. The difference between the calculated value and the observed value of bottom loss cannot be reconciled.

The procedure for calculating the bottom loss took the echo maximum peak excursion within the first 10 msecs. Equipment was not readily available for comparing the energy levels. Measurements of bottom loss made from the surface include the water column loss which is composed of spherical spreading and absorption. The latter is usually calculated from $0.01f^2$ db per kiloyard; this empirical formula has been derived from surface measurements in the horizontal plane and may well be false under conditions of high pressure.

The two sites although both very good reflectors, do show different acoustic properties. Site 1 is the smoother site, has an apparent thicker sediment covering but was also covered with the organic fuzz: the broadband bottom loss was -2.22 db. Site 2 was void of organic fuzz, had an apparent thinner sediment cover and was slightly rougher; the broadband bottom loss was -0.68 db. It is evident that bottom roughness is not the controlling factor in the acoustic return at either site, and assuming the sediment density and porosity are the same at both sites, the organic fuzz may be responsible for the higher bottom loss at Site 1.

CONCLUSIONS

1. Measurement of acoustic bottom loss at two sites from a submersible has produced results which are lower than those normally obtained by surface measurements.

2. Exhaustive analysis has shown that these results are factual and that individual measurements show no loss of energy on reflection.

3. The standard deviation of the grouped results is not as low as was expected; elimination of many of the variables associated with a surface orientated experiment could reasonably have been expected

to produce lower values, it would appear therefore, that the sediment properties themselves are responsible for the variations.

4. Further work of this nature is required to establish the mechanism of the low bottom loss experienced. Midwater experiments for instance should be performed.

References

1. Haigh K.R., "Shipborne Instrumentation for Continuous Recording of Acoustic Reflectivity of the Sea Bed and of Ocean Scattering Layers". Paper 22 I.E.R.E. Conference on Electronic Engineering in Oceanography Oct. 1966.

2. Haigh K.R., "The NAVADO/Summit Survey, Aims, Programme and Equipment". AUWE Technical Note 198/65 March 1966. (CONFIDENTIAL)

3. "Survey Requirements NAVOCEANO Marine Geophysical Program 65-67, Eastern and Central Atlantic Ocean, Norwegian and Mediterranean Seas" Naval Oceanographic Office December 1964.

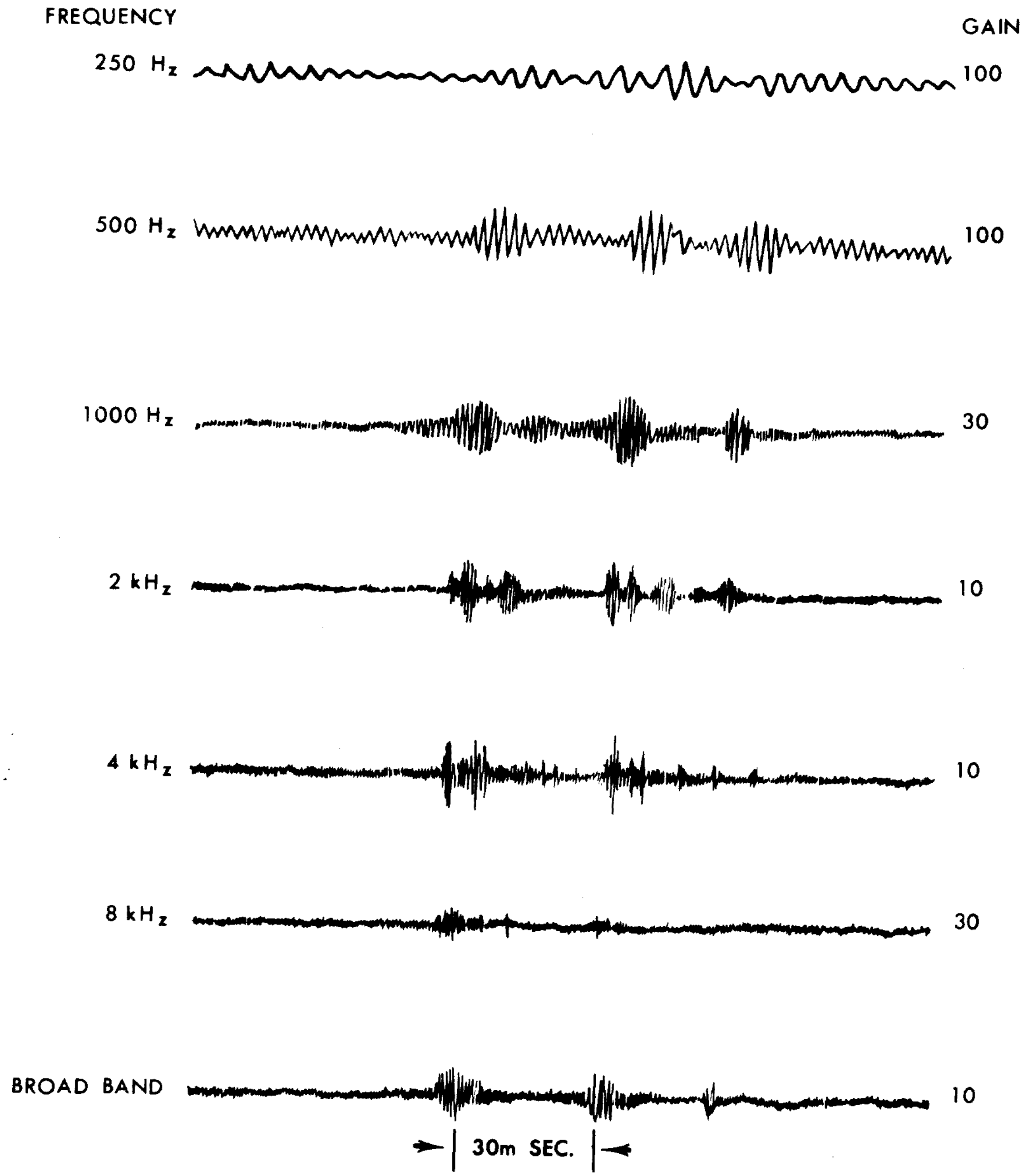

FIGURE 1 FILTERED SHOT CHARACTERISTICS

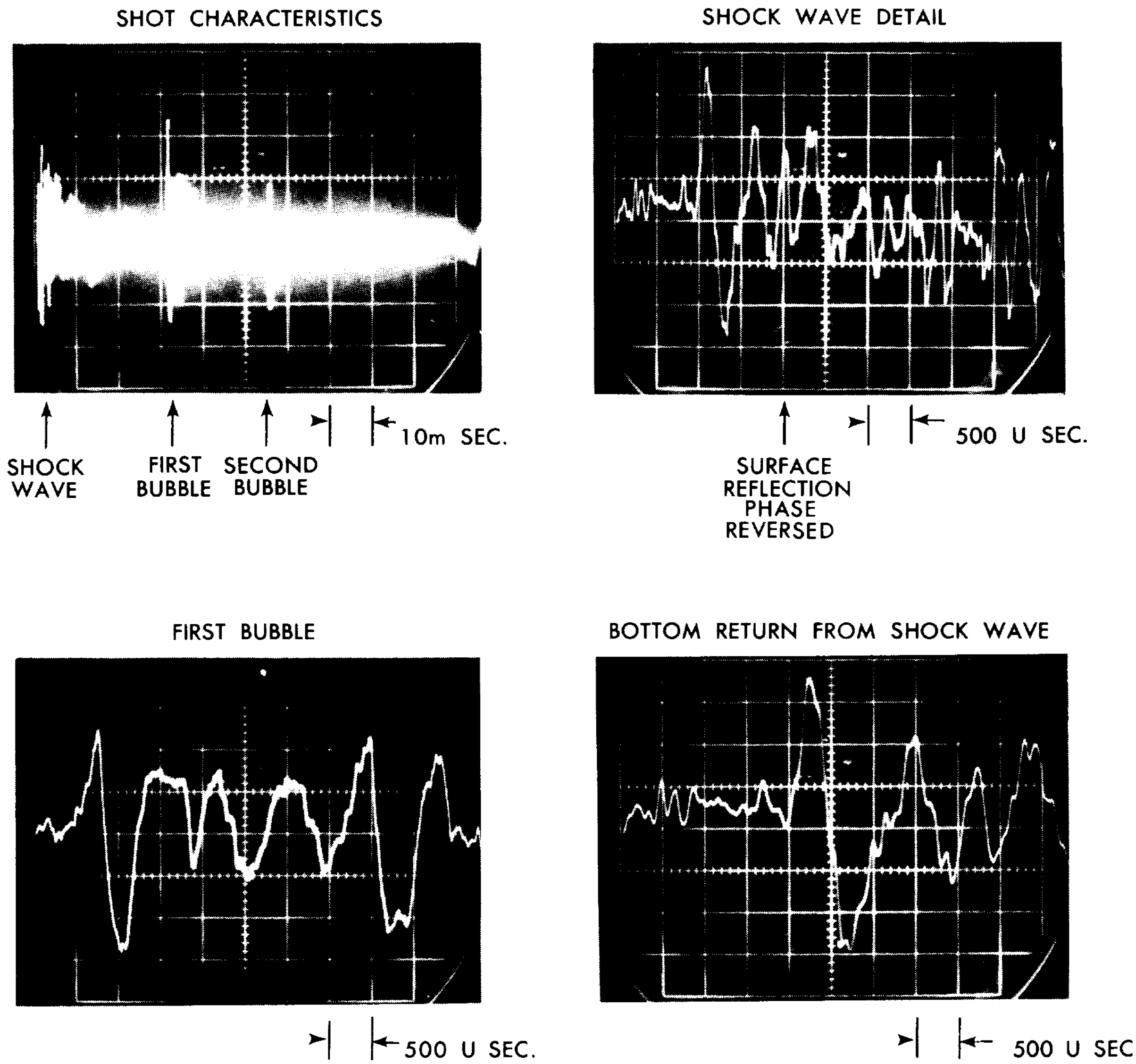

FIGURE 2 ACOUSTIC SIGNAL CHARACTERISTICS

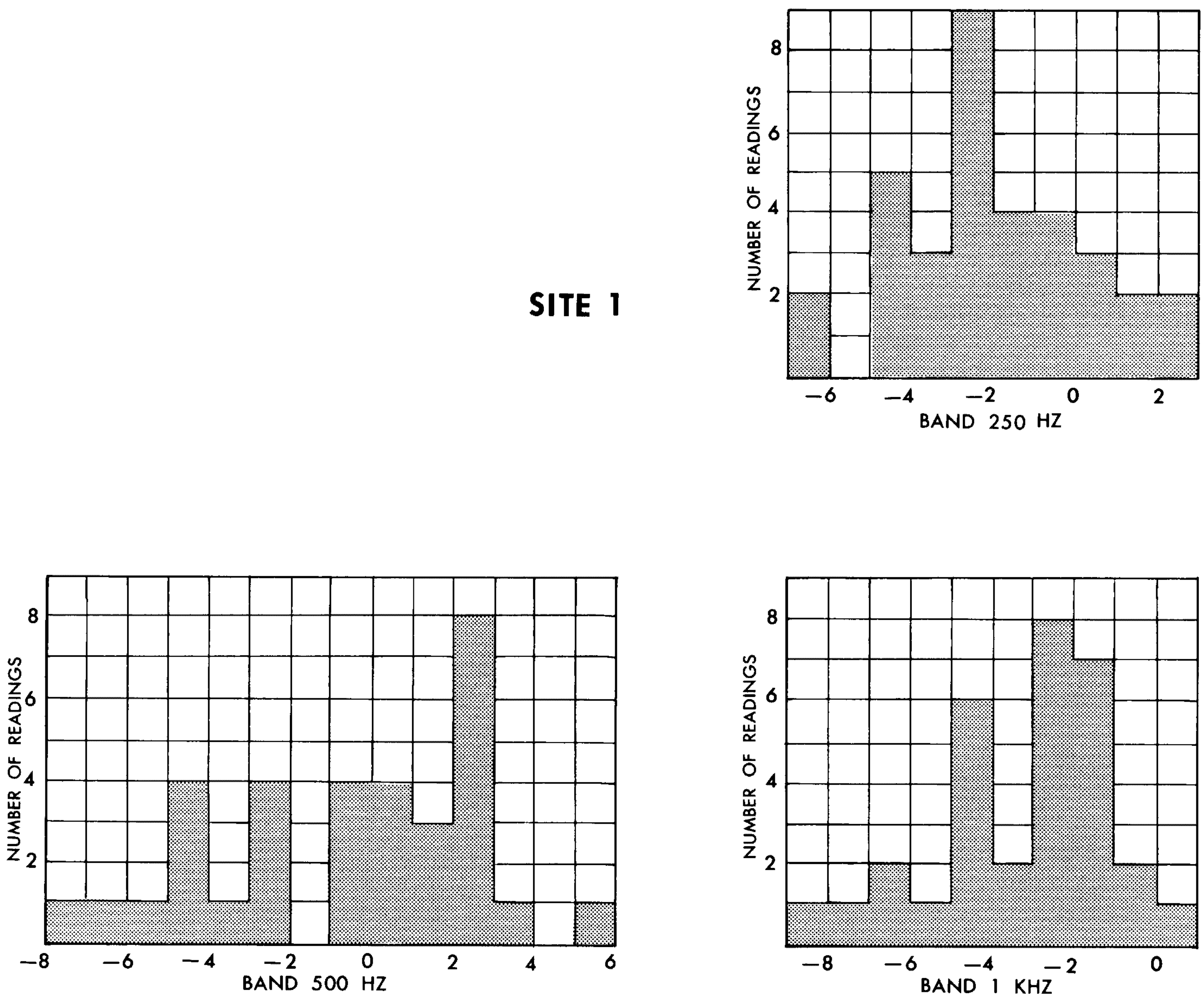

FIGURE 3 BOTTOM LOSS HISTOGRAM FOR 1/3 OCTAVE BANDS

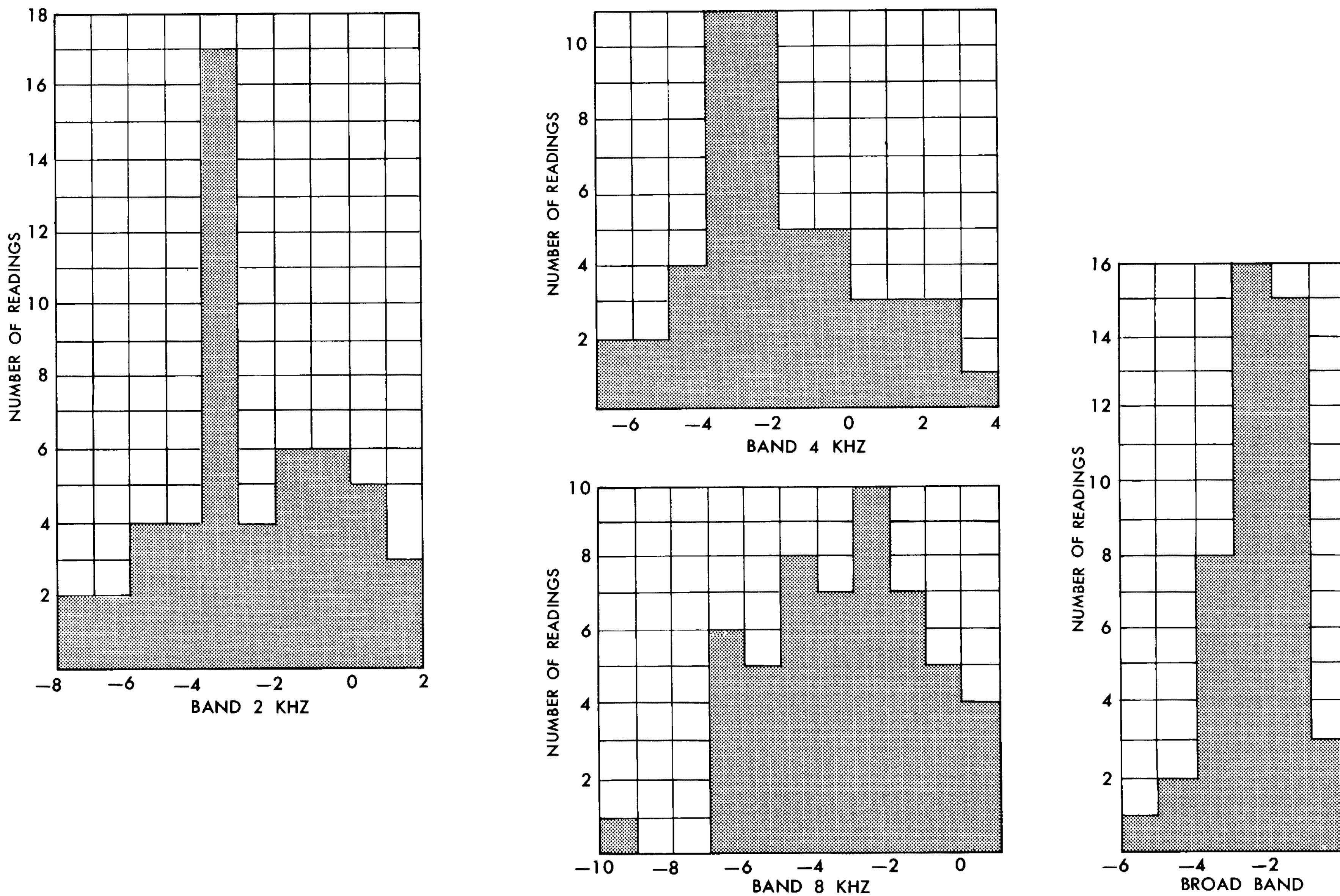

FIGURE 3 CONT.

SITE 2

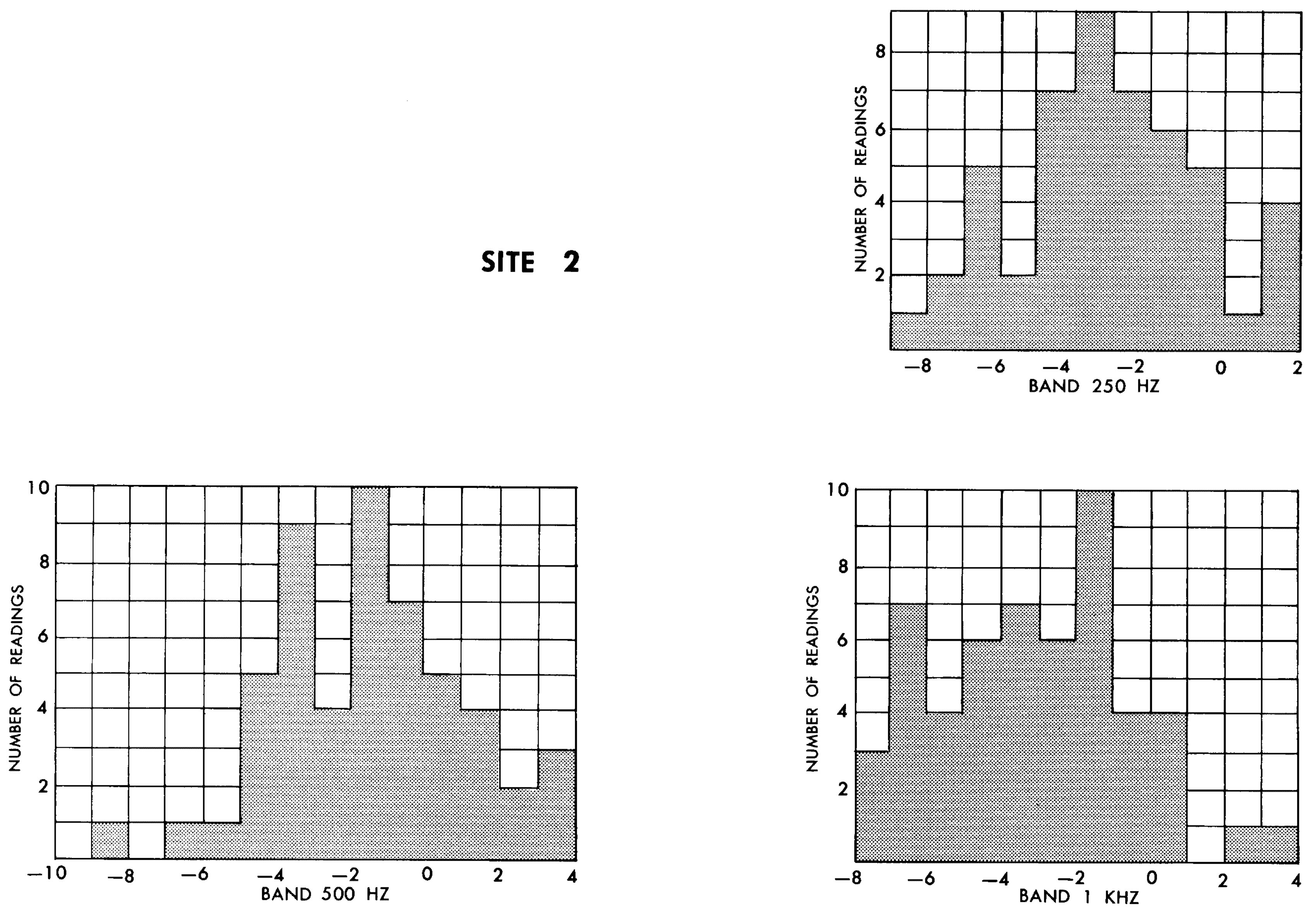

FIGURE 4 BOTTOM LOSS HISTOGRAM FOR 1/3 OCTAVE BANDS

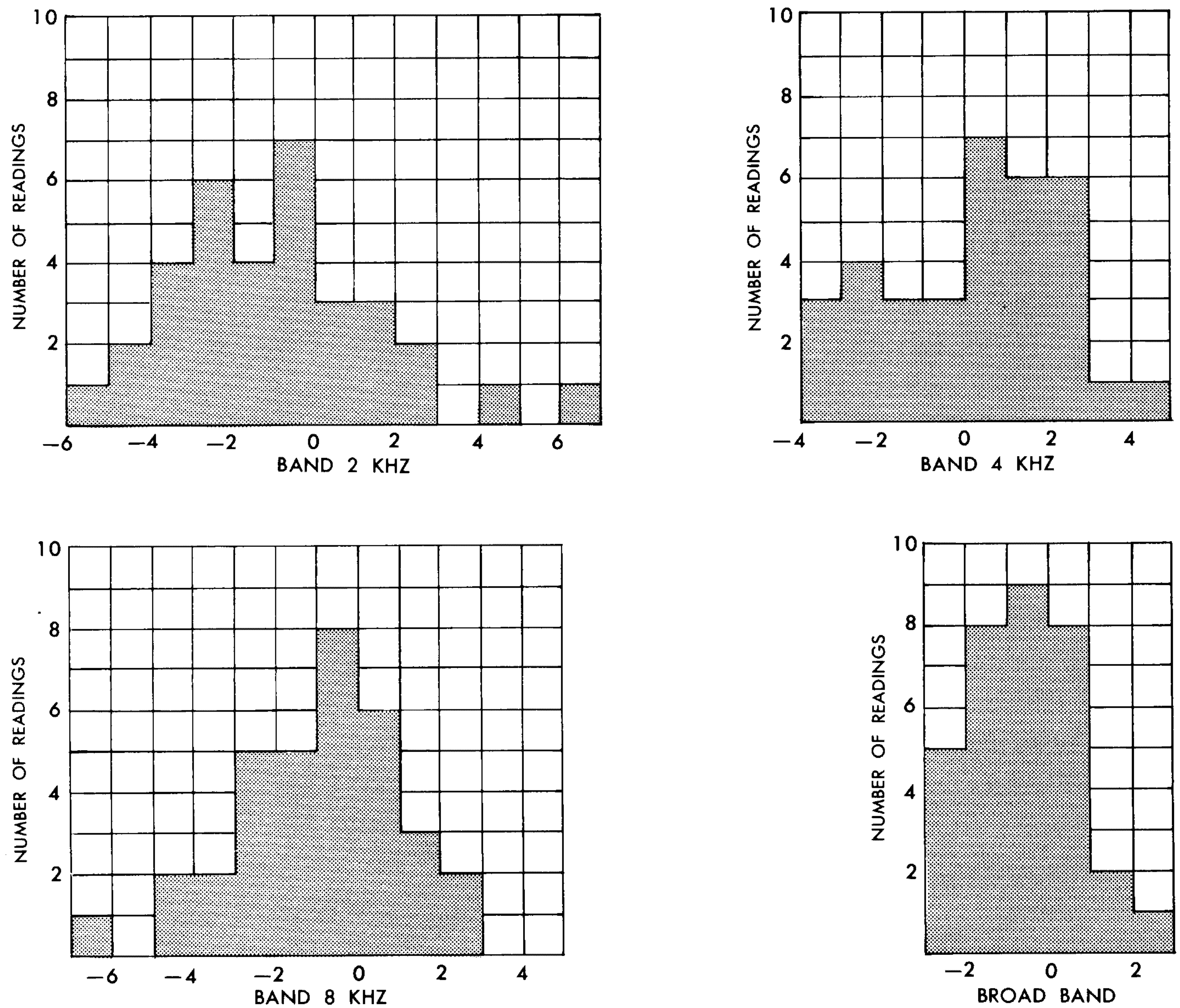

FIGURE 4 CONT.

MGG 9005051

SEDIMENT SIZE AND COMPOSITION DATA

CRUISE AFTUR   SAMPLE 25   LATITUDE 18 0.6 N   LONGITUDE 65 37.9 W
CORER TYPE 4   LENGTH 19.0cm   PENETRATION 79.0cm   DEPTH 1693.0 m

	ID. NO.	310 46	310 47	310 48	310 49
	INTERVAL	0.0- 6.0	6.0- 10.0	10.0- 13.0	13.0- 19.0
	MM	PERCENT	PERCENT	PERCENT	PERCENT
SAND	4.0000	0.000	0.000	0.000	0.000
	2.0000	0.061	0.000	0.000	0.419
	1.0000	0.307	0.311	0.345	0.629
	0.5000	1.533	13.043	3.448	5.241
	0.2500	1.839	35.714	4.483	9.434
	0.1250	4.905	7.764	4.828	5.451
	0.0625	11.956	2.795	7.931	6.499
SILT	0.0312	44.758	26.087	42.414	47.589
	0.0156	1.533	1.553	3.448	1.677
	0.0078	2.452	0.621	2.759	0.839
CLAY	0.0039	2.452	0.621	3.448	1.887
	0.0020	0.920	2.795	1.379	2.306
	0.0010	4.598	0.932	5.172	2.935
	0.0005	0.000	0.000	0.000	0.000
	0.0000-	22.685	7.764	20.345	15.094
	GRAVEL	0.061	0.000	0.000	0.419
	SAND	20.540	59.627	21.034	27.254
	SILT	51.196	28.882	52.069	51.992
	CLAY	28.204	11.491	26.897	20.335
	MEAN (MM)	0.0142	0.0911	0.0160	0.0279
	MEAN (PHI)	6.1395	3.4565	5.9655	5.1625
	STAN DEV	3.2991	3.0347	3.3323	3.2495
	SKEWNESS	0.3423	0.7291	0.2978	0.4105
	KURTOSIS	-0.9475	1.4132	-0.8413	-0.1611
	CACO3	81.000	83.000	84.000	88.000
	ORG CARBON	0.470	0.000	0.000	0.440
	COLOR	10YR7/4	10YR5/2	10YR8/2	5Y 8/1
	DOM MINERAL	GLOB	GLOB	GLOB	GLOB
	SEC MINERAL	PTEROPOD	PTER MICA	PTEROPOD	PTEROPOD

FIG 7

FIGURE 5
SITE 1 BOTTOM PHOTOGRAPH AREA 1.75m X 2m

23

FIGURE 6

SITE 2 BOTTOM PHOTOGRAPH AREA 1.75m X 2m

MGG09005051 25

UNCLASSIFIED

Security Classification

DOCUMENT CONTROL DATA - R & D

Security classification of title, body of abstract and indexing annotation must be entered when the overall report is classified)

1. ORIGINATING ACTIVITY (Corporate author) U.S. Naval Oceanographic Office Washington, D.C. 20390	2a. REPORT SECURITY CLASSIFICATION UNCLASSIFIED 2b. GROUP

3. REPORT TITLE

ACOUSTIC SEA BED REFLECTIVITY FROM A SUBMERSIBLE

4. DESCRIPTIVE NOTES (Type of report and inclusive dates)

Informal Report

5. AUTHOR(S) (First name, middle initial, last name)

Kenneth R. Haigh

6. REPORT DATE	7a. TOTAL NO. OF PAGES	7b. NO. OF REFS
March 1970	21	3

8a. CONTRACT OR GRANT NO.	9a. ORIGINATOR'S REPORT NUMBER(S)
b. PROJECT NO. 717	IR Number 70-13
c.	9b. OTHER REPORT NO(S) (Any other numbers that may be assigned this report)
d.	None

10. DISTRIBUTION STATEMENT

Distribution of this document is unlimited

11. SUPPLEMENTARY NOTES	12. SPONSORING MILITARY ACTIVITY
	U.S. Naval Oceanographic Office

13. ABSTRACT

Acoustic bottom reflectivity measurements made from the submersible ALUMINAUT at two sites in the Caribbean show unusually low bottom losses compared to similar measurements made in the past from surface ships. The reason for these low losses is explored but no satisfactory theory can be postulated. The submersible technique is inherently superior to that usually deployed from a surface ship and removes many of the variables associated with a surface experiment. Further experimentation is required to develop the technique and confirm the low losses.

DD FORM 1 NOV 65 1473 (PAGE 1)

S/N 0101-807-6801

UNCLASSIFIED

Security Classification

14 KEY WORDS	LINK A		LINK B		LINK C	
	ROLE	WT	ROLE	WT	ROLE	WT
Bottom reflectivity						
Submersible						
ALUMINAUT						